Chapter 1

Introduction

1.1 Why This Text?

During the period 1983-88, a series of experiments (Table 1.1) were undertaken by the Electrical Engineering Research Laboratory of The University of Texas and the Applied Physics Laboratory of The Johns Hopkins University in which propagation impairment effects were investigated for Land Mobile Satellite Service (LMSS) configurations. Other significant LMSS propagation investigations were performed in the United States [Hess, 1980], in Canada [Butterworth, 1984a; 1984b], and in Europe [Jongejans et al., 1986]. More recently, LMSS propagation measurements were reported from Australia [Bundrock, 1988], and England [Renduchintala et al., 1990].

The results described here are mostly derived from systematic studies of propagation effects for LMSS geometries in the United States associated with rural and suburban regions. Descriptions of these efforts have appeared in a number of technical reports, conference proceedings and publications. The rationale for the development of this text was to locate the salient and useful experimental and modeling results in one single document for use by communications engineers, designers of planned LMSS communications systems, and modelers of propagation effects. This text should complement the Handbook by Flock [1987], where fundamental propagation effects are described for satellite systems operating at frequencies below 10 GHz.

Where applicable, the authors have also liberally drawn from the results of the other related investigations. The results are presented in a "user friendly style" in the form of graphs, tables, and "best fit" analytic functions.

1.2 Background

Propagation experiments were performed by the authors in the Southern United States (New Mexico to Alabama), Virginia, Maryland, Colorado, and South-Eastern Australia. These experiments were executed with transmitters on stratospheric balloons, remotely piloted aircraft, helicopters, and geostationary satellites (MARECS B-2, Japanese ETS-V, and INMARSAT Pacific). The earlier experiments were performed at UHF (870 MHz), followed by simultaneous measurements at L-Band (1.5 GHz) and UHF. The satellite measurements were performed only at L-Band. During these experiments, the receiver system was located in a van outfitted with the UHF and L-Band antennas on its roof, and receivers and data acquisition equipment in its interior.

1.3 Objectives

The general objectives of the above tests were to assess the various types of impairments to propagation caused by trees and terrain for predominantly rural and suburban regions where terrestrial cellular communication services are presently non-existent and commercially impractical. Data acquired from the above experiments and other investigations have provided insight into the following LMSS propagation related characteristics described in this text:

- Attenuation and attenuation coefficients due to various tree types for non-mobile cases and their relation to elevation angle and frequency (Chapter 2).
- Attenuation statistics for mobile cases of roadside trees, including angular, seasonal, and frequency effects (Chapter 3).
- Attenuation statistics for mobile cases of mountainous and roadside tree environments, where line-of-sight propagation is maintained (Chapter 4).

- Fade duration, non-fade duration and phase characteristics for road-side tree environments (Chapter 5).
- Effects on fade statistics employing different gain antennas, feasibility of frequency re-use, and space diversity modeling (Chapter 6).
- Modeling of propagation effects (Chapter 8).

Also included for completeness are comparisons of fade distribution measurements obtained from various experimenters from different countries (Chapter 7).

We emphasize L-Band since The World Administrative Radio Conference for Mobile Services (WARC-MOB-87) in 1987 had allocated frequencies in this band for both the uplink and downlink modes. In particular, the agreed uplink and downlink bands are: [1] 1631.5 to 1634.5 MHz and 1530 to 1533 MHz, respectively, and [2] 1656.5 to 1660.5 MHz and 1555 to 1559 MHz, respectively, where the first set of bands are to be shared with the maritime mobile satellite service [Bell, 1988].

The results and methods described here deal with propagation for mobile satellite geometries in suburban and rural environments for elevation angles generally above 15°. Results "not" covered are associated with measurements performed in urban environments which may efficiently be serviced by cellular communications. Also, not examined here are measurements which pertain to channel effects associated with wide bandwidth modulated signals; with the exception of fade and non-fade durations and phase spreads (Chapter 5).

Table 1.1: Land-mobile propagation measurement campaigns of EERL, University of Texas, and APL, The Johns Hopkins University.

Date	Source	Location	Freq.	Objectives	Ref
10/83	Balloon	East Texas to Louisiana	UHF	First U.S. data set for forested and rural roads (600 km), 15°–35°	V and H; 1988
1/84	Balloon	East Texas	UHF	150 km, 15°–30°	V and H; 1988
11/84	Balloon	East Texas to Alabama	UHF, L	Freq. comparison, variety of roads and terrain, 30°–50°	
6/85	Remotely piloted aircraft	VA	UHF	Single tree attenuation, stationary receiver	V and G; 1986
10/85	Helicopter	Central MD	UHF	Systematic roadside tree sampling, single tree attenuation in fall foliage	G and V; 1987
3/86	Helicopter	Central MD	UHF	Systematic roadside tree sampling, no foliage	G and V; 1987
7/86	Balloon	East Texas to New Mexico	UHF, L	Open terrain, optical sensor, scatter model, 20°–60°	V and H; 1988
8/86	Helicopter	Colorado	UHF, L	Mountain roads, canyons, multipath limits	V and G; 1988
6/87	Helicopter	Central MD	UHF, L	Systematic roadside tree sampling, full foliage	G and V; 1989
12/87	MARECS-B2	Central MD	L	Systematic roadside tree sampling, ERS model	V and G; 1990
10/88	ETS-V and INMARSAT	S.E. Austral.	L	Systematic roadside tree sampling, fade durations, diversity, cross polarization	V et al.; 1991 H et al.; 1991